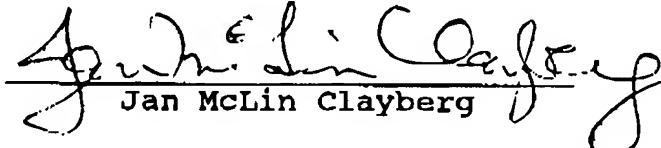


March 24, 2005

DECLARATION

The undersigned, Jan McLin Clayberg, having an office at 5316 Little Falls Road, Arlington, VA 22207-1522, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of international patent application PCT/DE 03/03438 of Merkel, R., et al., entitled "METHOD AND ARRANGEMENT FOR EVALUATING SIGNALS OR DATA FROM A SYSTEM FOR DETECTING OBJECTS".

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.


Jan McLin Clayberg

1
2
3 METHOD AND ARRANGEMENT FOR EVALUATING SIGNALS OR DATA FROM A
4 SYSTEM FOR DETECTING OBJECTS
5

6 Prior Art

7
8 The invention relates to a method and an arrangement
9 for evaluating signals or data from a system for detecting
10 objects, in particular for a motor vehicle, as generically
11 defined by the preamble to the main claim.

12
13 Such a system may be employed for instance in
14 adaptively regulating the travel speed of a motor vehicle
15 and/or its distance from other objects. This regulation known
16 per se can, without intervention by the driver, regulate a
17 previously set travel speed and/or a previously set distance
18 from a vehicle ahead, from objects located in the travel
19 direction. This is done by taking into account the area
20 around the motor vehicle and optionally still other
21 parameters, such as weather and visibility conditions. Such
22 regulation is also known as an adaptive cruise control system
23 (ACC system). The ACC system must in particular, given the
24 increasing density of traffic at present, be flexible enough
25 to react suitably to all driving situations. This in turn
26 requires an appropriate object detection sensor system, so
27 that the measurement data required for the regulation will be
28 furnished in every driving situation.

29
30 Sensors for an ACC system are known per se, as a rule
31 having radar sensors or lidar, that have a range of about 100
32 to 150 m, with a detection angle of approximately 10\|. Short-
33 range distance sensors for parking assistance systems are
34 also known per se, which are predominantly equipped with
35 ultrasonic sensors.

36

1 It is known for instance from German Patent Disclosure
2 DE 44 42 189 A1 that in a system for distance measurement in
3 the area surrounding motor vehicles, sensors with transceiver
4 units are used for both sending and receiving information.
5 With the aid of the distance measurement, passive protection
6 measures for the vehicle can be activated, for instance in
7 the event of a front, side or rear-end collision. With an
8 exchange of the information detected, an assessment of
9 traffic situations can for instance be made for activating
10 appropriate tripping systems.

11
12 It is furthermore known from German Patent Disclosure
13 DE 199 63 005 A1 that a distance measurement can be performed
14 with so-called pulse radar, in which a carrier pulse with a
15 rectangular envelope of electromagnetic oscillation, for
16 instance in the Gigahertz range, is transmitted. This carrier
17 pulse is reflected from the target object, and from the time
18 between the emission of the pulse and the arrival of the
19 reflected radiation, the distance from the target and, with
20 limitations, using the Doppler effect, the relative speed of
21 the target object can also be easily determined. Such a
22 measurement principle is described for instance in the
23 textbook by A. Ludloff, "Handbuch Radar und
24 Radarsignalverarbeitung" [Radar and Radar Signal Processing
25 Manual], pages 2-21 to 2-44, published by Vieweg Verlag,
26 1993.

27
28 The basic layout of such a known radar sensor is
29 designed such that the radar pulses reflected from the
30 particular target object reach a receiver via antennas and
31 are mixed in the receiver with the delayed pulses furnished
32 by the pulse generator. The output signals of the receivers
33 are delivered, after low-pass filtration and analog/digital
34 conversion, to an evaluation unit.

1
2 In the aforementioned various applications, it is often
3 necessary to use a so-called platform sensor for the various
4 applications, such as parking assistance, precrash, ACC-
5 Stop&Go, or TWD (for the German for Idle Angle Detector).
6 Because of the properties of the sensor signals, however,
7 this requires a certain intelligence in the sensor, which
8 enables optimal evaluation of the sensor signal with regard
9 to the various evaluation criteria. This evaluation must be
10 optimized for cost reasons on the one hand, without on the
11 other limiting the freedom for further developments in the
12 future.

13
14 In particular, a switchover capability for switching
15 from a distance measurement to a so-called Cv measurement,
16 that is, determining the approach speed before a possible
17 collision of vehicles (closing velocity (Cv) for precrash),
18 should be able to run as simply as possible. So-called
19 distance lists would be possible here, which can be forwarded
20 to a control unit, but the various applications mentioned
21 above require different kinds of distance lists. As a rule,
22 very complicated application-specific algorithms in the
23 sensor are required, by which different information must then
24 be forwarded to the control unit, which leads to relatively
25 high transmission rates at the interface between the sensor
26 and the control unit. Care must also be taken, for reasons of
27 cost and to simplify the circuitry, to use components for the
28 interface that are already used in other areas in the
29 vehicle, including in applications that are critical to
30 safety.

31
32 Advantages of the Invention
33

34 A system for detecting objects, in particular for a

1 motor vehicle, and a method for evaluating the data signals
2 occurring in it, in which with a radar sensor the radar
3 signals reflected from the object are processed for
4 ascertaining the distance and/or the relative or approach
5 speed of the object, is advantageously further embodied
6 according to the invention as follows. The digital signals
7 from at least one channel of the radar sensor are processed
8 only until a first evaluation capability is found as a
9 distance signal or an approach speed signal. That is, the
10 signal processing in the radar sensor is done only up to the
11 signals that for the first time permit a simple physical
12 interpretation.

13

14 Advantageously, a mode switchover for the evaluation as
15 a distance signal as an approach speed signal can be
16 effected, with which it is defined which data will be
17 ascertained and made available to an interface between the
18 radar sensor and a downstream control unit.

19

20 In a manner known per se, the digital signals from at
21 least one channel, but preferably two channels I and Q of the
22 radar sensor, after every sampling operation, can be
23 delivered respectively to a data buffer of predetermined slot
24 width and then processed within the slot width, for instance
25 by means of a median filtration operation. For calculating
26 the background by means of the median filtration, the
27 digitized raw signals from the I and Q channels are thus
28 delivered after each sampling operation to a data buffer of a
29 determined slot width (such as 16 words). If the word width
30 is 16 bits, some bits can be used for the analog/digitally
31 converted values. Other bits may also serve as an auxiliary
32 variable for the sorting algorithm for the median
33 calculation, such as the age of the value, as a number
34 between 0 and the slot width of -1.

1
2 In the next processing step, the aforementioned
3 background correction is then effected along with a gain
4 compensation, which may be required under some circumstances,
5 between the I and Q channels. If necessary, the parameters
6 pertaining to this may also be stored in a nonvolatile,
7 read/write memory. This is then followed by the
8 rationalization from the I and Q channels.

9
10 The signal data calculated in this way may also, with
11 relatively little expense for resources, also be correlated
12 in a matching filter with a reference signal course or
13 reference peak in order to improve the signal-to-signal noise
14 ratio, so that now only information about the result of
15 correlation has to be further transmitted. In principle, for
16 the distance measurement, now only a peak search algorithm is
17 needed to arrive at the distance data.

18
19 The method of the invention is especially advantageous
20 because in it a simple switchover to the so-called Cv mode,
21 that is, ascertaining the approach speed of an object, can be
22 performed and the background correction and rationalization
23 described above can be dispensed with. The raw signals are
24 recorded continuously within a range gate. Since in this
25 evaluation mode the corresponding algorithm is examined for
26 each sampled value, the data are available in real time in
27 the connected control unit; that is, a requirement of a
28 switchover time of 10 ms, for instance, for switching from
29 distance measurement to the Cv mode can also be met for the
30 precrash mode.

31
32 In the further course of the method of the invention, a
33 data compression, which can be influenced by an external
34 control unit, for instance, can also be done in a simple way.

1 For instance, so-called calibration coefficients and measured
2 values from the Cv mode, because of the small quantities of
3 data, need not necessarily be sent in compressed form via the
4 interface.

5

6 In an advantageous circuit arrangement for performing
7 the method described above, a radar sensor has storage means
8 and digital computation modules for performing and switching
9 over the evaluation modes mentioned. In the radar sensor
10 there is an interface controller, by way of which the radar
11 sensor can be connected to a downstream control unit. The
12 interface controller can be constructed such that the data
13 are prepared for connection to a standardized bus system,
14 such as the so-called CAN bus in a motor vehicle.

15

16 In an especially advantageous embodiment of the
17 invention, a data processing program for performing the
18 method of the invention or controlling the storage means
19 and/or the digital computation modules in the radar sensor
20 can be constructed such that the appropriate evaluation modes
21 can be performed quickly and in a way that is economical in
22 terms of resources.

23

24 In summary, transmitting background-corrected raw
25 signals with a rationalization for the distance measurement
26 has a number of advantages, especially because the data are
27 easily interpreted and a data reduction from two channels (I
28 and Q channels) can be ascribed to one data set. The
29 previously usual transmission of purely raw signals
30 conversely requires a high interface bandwidth, and the
31 signals can be interpreted only with difficulty. Thus for the
32 various applications, no changes need to be made in the basic
33 signal processing or in the sensor, and as a result the
34 signal processing functions in principle as a so-called black

1 box .

2

3 A further data compression can be performed for
4 instance by forwarding differential changes to the preceding
5 measured value, and as a result the data transmission can be
6 done by way of suitable inexpensive, proprietary interfaces.
7 The data transmission rate, which can be reduced by data
8 compression, is lower than the currently usable interface
9 bandwidths of proprietary bus systems, such as a CAN bus, or
10 other suitable interfaces.

11

12 This not only makes signal processing economical but at
13 the same time also makes it possible to market the radar
14 sensors even without an associated control unit. Since memory
15 modules are as a rule more economical in the universally
16 constructed control unit than in the specially constructed
17 radar sensor, still further cost advantages are obtained.

18

19 The degree to which the signals are processed until
20 after the rationalization and optionally also after the
21 matching filter is secure in this respect even for future
22 developments, since superimposed algorithms from the various
23 applications in the control unit can be optimized
24 independently of one another and independently of a software
25 program in the radar sensor, for instance for detecting slow-
26 moving and fast-moving objects.

27

28 Drawing

29

30 The method of the invention for evaluating the data
31 from a system for detecting objects will be described in
32 conjunction with the drawing, which shows a schematic block
33 diagram of the course of the method.

34

1 Description of the Exemplary Embodiment

2
3 The sole drawing figure is a schematic block circuit
4 diagram which shows the evaluation of signals, for instance
5 from a pulse-modulated microwave radar, with a transmitter,
6 operating for instance at a frequency of 24 GHz, and with
7 receiver and mixing units. One such radar sensor is described
8 in DE 199 63 005 A1 mentioned above as prior art; in this
9 respect the furnishing of an I channel and a Q channel for
10 determining the distance and relative speed values is
11 described per se.

12
13 According to the block circuit diagram in the sole
14 drawing figure, the signals, digitized at a predetermined
15 resolution (ADC resolution), from the channels I and Q of a
16 radar sensor shown here are delivered after each sampling
17 operation to a respective data buffer (shown symbolically in
18 blocks 1 and 2) with a predetermined slot width, such as 16
19 words ($\text{age}(n=\log_2(\text{window width}))$), and then are processed
20 within the slot width by means of a median filtration
21 operation with a resolution $m = \text{ADC}$. The values m and n here
22 represent the associated number of bits.

23
24 In the next method step, in block 3, a background
25 correction is then effected for the channels I and Q jointly
26 for the distance measurement of an object (d measurement), in
27 which now only signal deflections from an ascertained
28 background signal are further processed. If necessary, a gain
29 compensation between the I and Q channels that may be
30 necessary under some circumstances can be performed, and this
31 is then followed by the computed rationalization of the
32 signals from the I and Q channels.

33
34 In block 3 of the drawing, a routine is also shown with

1 which the signal data calculated in this way are optionally
2 correlated in a matching filter with a reference signal
3 course or reference peak, so that now only information about
4 the outcome of correlation needs to be further transmitted.

5

6 A further block 4 identifies a routine with which a
7 switchover of the evaluation mode in block 3 to the so-called
8 Cv mode, that is, ascertaining the approach speed of an
9 object, can be performed. The background correction described
10 above and the rationalization can then be dispensed with, so
11 that the raw signals are recorded continuously inside a range
12 gate, and in the control unit now only the zero crossovers of
13 the raw signal are evaluated. Since in this evaluation mode
14 the corresponding algorithm is examined for each sampled
15 value, the data are then present in real time; that is, the
16 requirement for 10 ms, for instance, of switchover time from
17 the distance measurement to the Cv mode can be met for the
18 precrash mode as well. In block 4, routines for furnishing
19 calibration coefficients and parameters for the
20 aforementioned gain compensation in block 3 can also be
21 furnished.

22

23 In block 5, a data compression is indicated, and in
24 block 6, an interface controller is shown, which makes its
25 output signals available to an external control unit 7. The
26 interface controller in block 6 can be constructed such that
27 the data for connection to a standardized bus system, for
28 instance the so-called CAN bus in a motor vehicle, are
29 prepared.

30

31 The activation of the data compression can be varied,
32 for instance by the external control unit 7 via the interface
33 controller 6, by a diagnostic or servicing computation module
34 8, or by the block 4 for controlling the evaluation mode. For

1 example, the calibration coefficients and the measured values
2 in the Cv mode, because of the slight data quantities, need
3 not necessarily be sent in compressed form.

4

5 In block 9, a delay triggering means is also shown,
6 with which in a manner known per se a trigger for the
7 starting and ending values in the transmission of the raw
8 signals of the radar sensor is controlled.